VOLTAGE REGULATOR

R×5RL SERIES

APPLICATION MANUAL

RICOH

ELECTRONIC DEVICES DIVISION

NO.EA-022-9803

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7. Anti-radiation design is not implemented in the products described in this application manual.

8. Please contact Ricoh sales representatives should you have any questions or comments concerning the products or the technical information.

June 1995

R×5RL SERIES

APPLICATION MANUAL

CONTENTS

R×5RL SERIES

OUTLINE

The R×5RL Series are voltage regulator ICs with high accuracy output voltage and ultra-low quiescent current by CMOS process. Each of these ICs consists of a voltage reference unit, an error amplifier, a driver transistor, and resistors for setting output voltage. The output voltage is fixed with high accuracy.

Three types of packages, TO-92, SOT-89 (Mini-power Mold), SOT-23-5 (Mini-mold), are available.

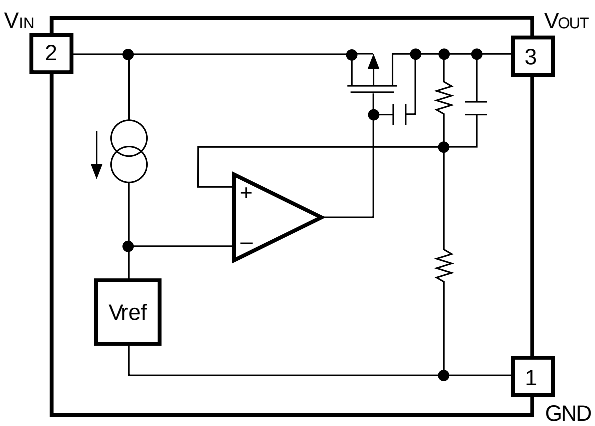
FEATURES

- Ultra-low Quiescent Current ··························TYP. 1.1µA (R×5RL30A, V_{IN}=5.0V)
- Small Dropout Voltage ·································TYP. 30mV (R×5RL50A, I_{OUT}=1mA)
- Low Temperature-Drift Coefficient of Output Voltage ··············TYP. ±100 ppm/°C
- Excellent Line Regulation ·······························TYP. 0.1%/V
- Output Voltage ···Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V is possible (refer to Selection Guide).
- High Accuracy Output Voltage ·························±2.5%
- Three Types of Packages ································TO-92, SOT-89 (Mini-power Mold), SOT-23-5 (Mini-mold)

APPLICATIONS

- Power source for battery-powered equipment.
- Power source for cameras, video instruments such as camcorders, VCRs, and hand- held communication equipment.
- Precision voltage references.

BLOCK DIAGRAM



SELECTION GUIDE

The package type, the output voltage, the packing type, and the taping type of R×5RL Series can be designated at the user's request by specifying the part number as follows:

$$\mathrm{R{\times}5RL}\underbrace{\times\times}_{b}\underbrace{\times}_{c}\underbrace{\times}_{d}-\underbrace{\times\times}_{e} \leftarrow \text{Part Number}$$

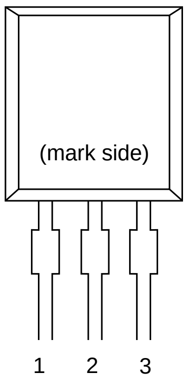
↑ a (R×) ; b c d ; e

Code	Contents
a	Designation of Package Type: E: TO-92 H: SOT-89 (Mini-power Mold) N: SOT-23-5 (Mini-mold)
b	Setting Output Voltage (VOUT): Stepwise setting with a step of 0.1V in the range of 2.0V to 6.0V is possible.
c	A
d	Designation of Packing Type: A: Taping C: Antistatic bag for TO-92 and samples
e	Designation of Taping Type: Ex. TO-92 : RF, RR, TZ SOT-89 : T1, T2 SOT-23-5 : TR, TL (refer to Taping Specifications) “TZ”, “T1”, and “TR” are prescribed as a standard.

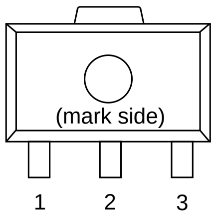
For example, the product with Package Type SOT-89, Output Voltage 5.0V, Version A,and Taping Type T1 are designated by Part Number RH5RL50AA-T1.

PIN CONFIGURATION

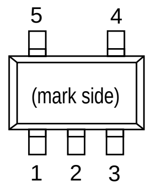
• TO-92



• SOT-89



• SOT-23-5



PIN DESCRIPTION

• TO-92

Pin No.	Symbol
1	GND
2	V_{IN}
3	V_{OUT}

• SOT-89

Pin No.	Symbol
1	GND
2	V_{IN}
3	V_{OUT}

• SOT-23-5

Pin No.	Symbol
1	GND
2	V_{IN}
3	V_{OUT}
4	NC
5	NC

ABSOLUTE MAXIMUM RATINGS

Topt=25°C

Symbol	Item	Rating	Unit
V_{IN}	Input Voltage	+12	V
V_{OUT}	Output Voltage	–0.3 to V_{IN} +0.3	V
I_{OUT}	Output Current	150	mA
P_D1	Power Dissipation 1 (NOTE1)	300	mW
P_D2	Power Dissipation 2 (NOTE2)	150	mW
Topt	Operating Temperature	– 30 to +80	°C
Tstg	Storage Temperature	– 55 to +125	°C
Tsolder	Lead Temperature (Soldering)	260°C,10s	

(NOTE 1) applied to SOT-89 and TO-92
(NOTE 2) applied to SOT-23-5

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum ratings are threshold limit values that must not be exceeded even for an instant under any conditions. Moreover, such values for any two items must not be reached simultaneously. Operation above these absolute maximum ratings may cause degradation or permanent damage to the device. These are stress ratings only and do not necessarily imply functional operation below these limits.

ELECTRICAL CHARACTERISTICS

- **R×5RL20A**

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=4.0V 10μA≤I_{OUT}≤10mA	1.950	2.000	2.050	V
I_{OUT}	Output Current	V_{IN}=4.0V	25	35		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V_{IN}=4.0V 1mA≤I_{OUT}≤35mA		30	45	mV
V_{DIF}	Dropout Voltage	I_{OUT}=1mA		60	90	mV
I_{SS}	Quiescent Current	V_{IN}=4.0V		1.0	3.0	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I_{OUT}=1mA V_{OUT}+0.5V≤V_{IN}≤10V		0.05	0.2	%/V
V_{IN}	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta Topt}$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –30°C≤Topt≤80°C		±100		ppm/°C

- **R×5RL30A**

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=5.0V 10μA≤I_{OUT}≤10mA	2.925	3.000	3.075	V
I_{OUT}	Output Current	V_{IN}=5.0V	35	50		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V_{IN}=5.0V 1mA≤I_{OUT}≤50mA		40	60	mV
V_{DIF}	Dropout Voltage	I_{OUT}=1mA		40	60	mV
I_{SS}	Quiescent Current	V_{IN}=5.0V		1.1	3.3	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I_{OUT}=1mA V_{OUT}+0.5V≤V_{IN}≤10V		0.05	0.2	%/V
V_{IN}	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta Topt}$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –30°C≤Topt≤80°C		±100		ppm/°C

• R×5RL40A

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=6.0V 10µA≤I_{OUT}≤10mA	3.900	4.000	4.100	V
I_{OUT}	Output Current	V_{IN}=6.0V	45	65		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V_{IN}=6.0V 1mA≤I_{OUT}≤65mA		50	75	mV
V_{DIF}	Dropout Voltage	I_{OUT}=1mA		25	38	mV
I_{SS}	Quiescent Current	V_{IN}=6.0V		1.2	3.6	µA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I_{OUT}=1mA V_{OUT}+0.5V≤V_{IN}≤10V		0.05	0.2	%/V
V_{IN}	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta Topt}$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –30°C≤Topt≤80°C		±100		ppm/°C

• R×5RL50A

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=7.0V 10µA≤I_{OUT}≤10mA	4.875	5.000	5.125	V
I_{OUT}	Output Current	V_{IN}=7.0V	55	80		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V_{IN}=7.0V 1mA≤I_{OUT}≤80mA		60	90	mV
V_{DIF}	Dropout Voltage	I_{OUT}=1mA		25	38	mV
I_{SS}	Quiescent Current	V_{IN}=7.0V		1.3	3.9	µA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I_{OUT}=1mA V_{OUT}+0.5V≤V_{IN}≤10V		0.05	0.2	%/V
V_{IN}	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta Topt}$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –30°C≤Topt≤80°C		±100		ppm/°C

• R×5RL60A

Topt=25°C

Symbol	Item	Conditions	MIN.	TYP.	MAX.	Unit
V_{OUT}	Output Voltage	V_{IN}=8.0V 10μA≤I_{OUT}≤10mA	5.850	6.000	6.150	V
I_{OUT}	Output Current	V_{IN}=8.0V	55	80		mA
$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	Load Regulation	V_{IN}=8.0V 1mA≤I_{OUT}≤80mA		60	90	mV
V_{DIF}	Dropout Voltage	I_{OUT}=1mA		25	38	mV
I_{SS}	Quiescent Current	V_{IN}=8.0V		1.3	3.9	μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Line Regulation	I_{OUT}=1mA V_{OUT}+0.5V≤V_{IN}≤10V		0.05	0.2	%/V
V_{IN}	Input Voltage				10	V
$\frac{\Delta V_{OUT}}{\Delta Topt}$	Output Voltage Temperature Coefficient	I_{OUT}=10mA –30°C≤Topt≤80°C		±100		ppm/°C

ELECTRICAL CHARACTEISTICS BY OUTPUT VOLTAGE

Part Number	Output Voltage V_{OUT}(V)				OutputCurrent I_{OUT}(mA)			Load Regulation ΔV_{OUT}(mV)			Dropout Voltage V_{DIF} (mV)		
	Conditions	MIN.	TYP.	MAX.	Conditions	MIN.	TYP.	Conditions	TYP.	MAX.	Conditions	TYP.	MAX.
R×5RL20A	$V_{IN}-V_{OUT}=2.0V$ $10\mu A \le I_{OUT} \le 10mA$	1.950	2.000	2.050	$V_{IN}-V_{OUT}=2.0V$	25	35	$V_{IN}-V_{OUT}=2.0V$ $1mA \le I_{OUT} \le 35mA$	30	45	$I_{OUT}=1mA$	60	90
R×5RL21A		2.048	2.100	2.152									
R×5RL22A		2.145	2.200	2.255									
R×5RL23A		2.243	2.300	2.357									
R×5RL24A		2.340	2.400	2.460								50	75
R×5RL25A		2.438	2.500	2.562									
R×5RL26A		2.535	2.600	2.665									
R×5RL27A		2.633	2.700	2.767									
R×5RL28A		2.730	2.800	2.870								40	60
R×5RL29A		2.828	2.900	2.972									
R×5RL30A		2.925	3.000	3.075		35	50	$V_{IN}-V_{OUT}=2.0V$ $1mA \le I_{OUT} \le 50mA$	40	60			
R×5RL31A		3.023	3.100	3.177									
R×5RL32A		3.120	3.200	3.280								35	53
R×5RL33A		3.218	3.300	3.382									
R×5RL34A		3.315	3.400	3.485									
R×5RL35A		3.413	3.500	3.587									
R×5RL36A		3.510	3.600	3.690								30	45
R×5RL37A		3.608	3.700	3.792									
R×5RL38A		3.705	3.800	3.895									
R×5RL39A		3.803	3.900	3.997									
R×5RL40A		3.900	4.000	4.100		45	65	$V_{IN}-V_{OUT}=2.0V$ $1mA \le I_{OUT} \le 65mA$	50	70		25	38
R×5RL41A		3.998	4.100	4.202									
R×5RL42A		4.095	4.200	4.305									
R×5RL43A		4.193	4.300	4.407									
R×5RL44A		4.290	4.400	4.510									
R×5RL45A		4.388	4.500	4.612									
R×5RL46A		4.485	4.600	4.715									
R×5RL47A		4.583	4.700	4.817									
R×5RL48A		4.680	4.800	4.920									
R×5RL49A		4.778	4.900	5.022									
R×5RL50A		4.875	5.000	5.125		55	80	$V_{IN}-V_{OUT}=2.0V$ $1mA \le I_{OUT} \le 80mA$	60	90			
R×5RL51A		4.973	5.100	5.227									
R×5RL52A		5.070	5.200	5.330									
R×5RL53A		5.168	5.300	5.432									
R×5RL54A		5.265	5.400	5.535									
R×5RL55A		5.363	5.500	5.637									
R×5RL56A		5.460	5.600	5.740									
R×5RL57A		5.558	5.700	5.842									
R×5RL58A		5.655	5.800	5.945									
R×5RL59A		5.753	5.900	6.047									

Topt=25°C

Quiescent Current			Line Regulation			Input Voltage	Output Voltage Tempco.	
Iss(μA)			$\Delta V_{OUT}/\Delta V_{IN}$(%/V)			V_{IN}(V)	$\Delta V_{OUT}/\Delta T$(ppm/°C)	
Conditions	TYP.	MAX.	Conditions	TYP.	MAX.	MAX.	Conditions	TYP.
V_{IN} V_{OUT} =2.0V	1.0	3.0	I_{OUT} =1mA V_{OUT}+ 0.5V≤ V_{IN}≤ ≤10V	0.05	0.2	10	I_{OUT} =10mA −30°C≤ Topt 80°C	±100
	1.1	3.3						
	1.2	3.6						
	1.3	3.9						

OPERATION

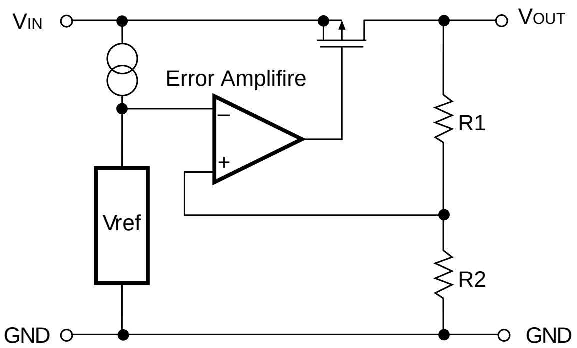


FIG. 1 Brock Diagram

Output Voltage VOUT divided at the node between Registers R1 and R2 is compared with Reference Voltage by Error Amplifier, so that a constant voltage is output.

TEST CIRCUITS

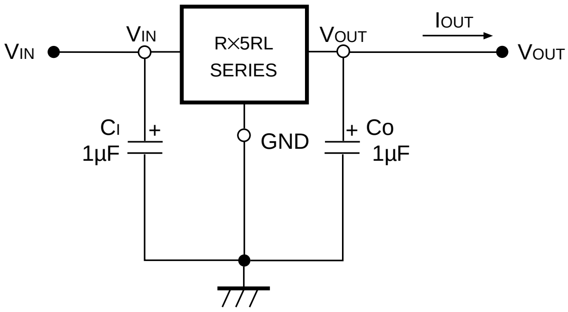


FIG. 2 Test Circuit

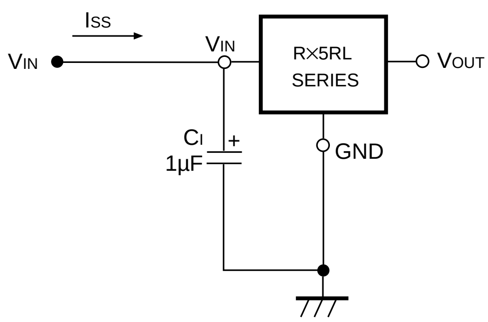


FIG. 3 Quiescent Current Test Circuit

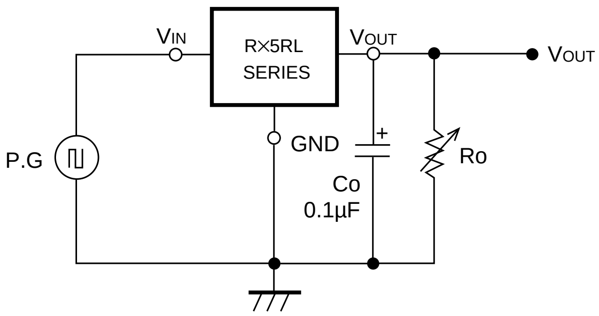


FIG. 4 Line Transient Response Test Circuit

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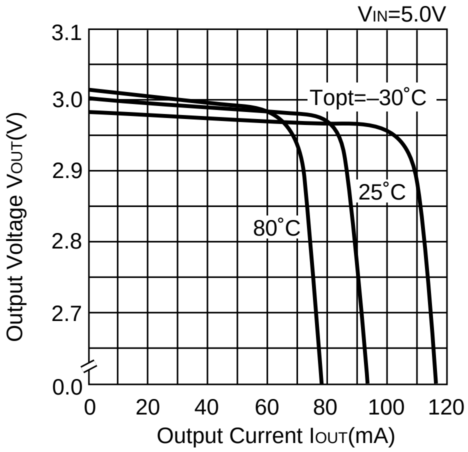
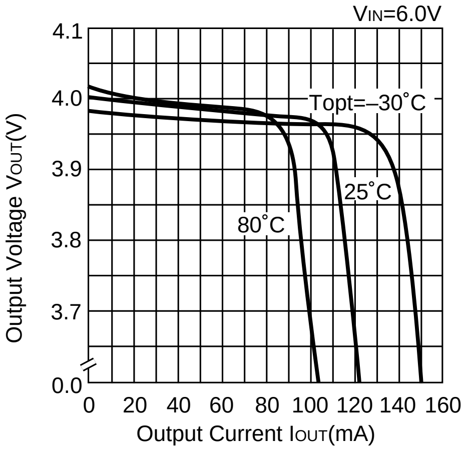
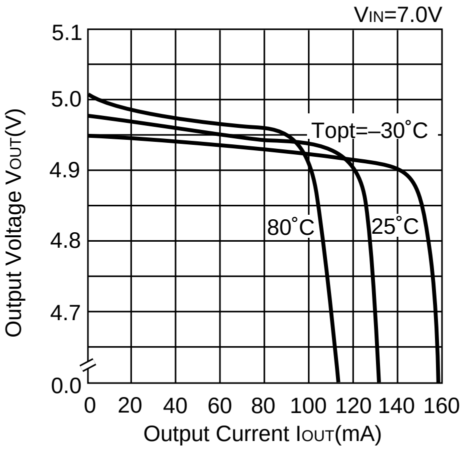
TYPICAL CHARACTERISTICS

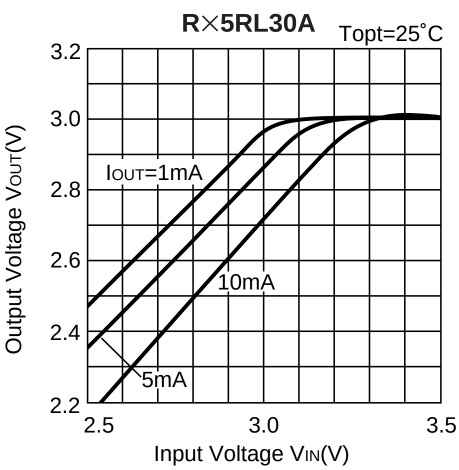
1) Output Voltage vs. Output Current

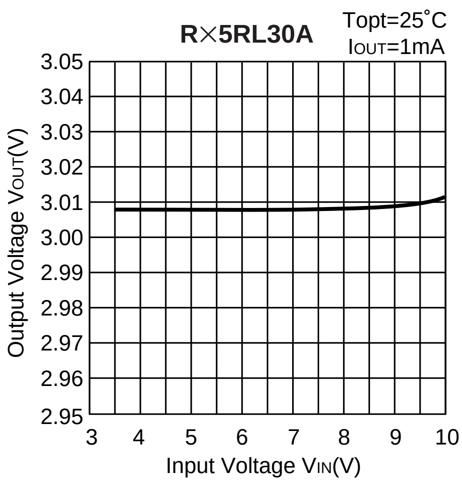


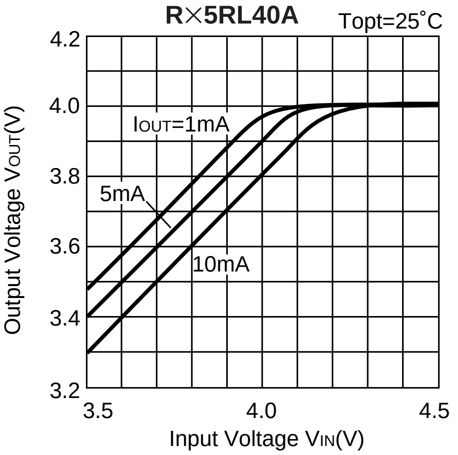


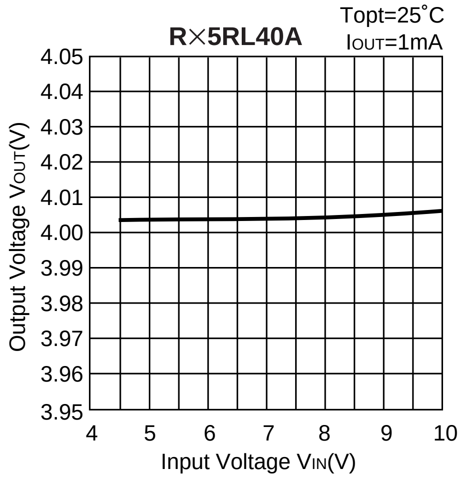


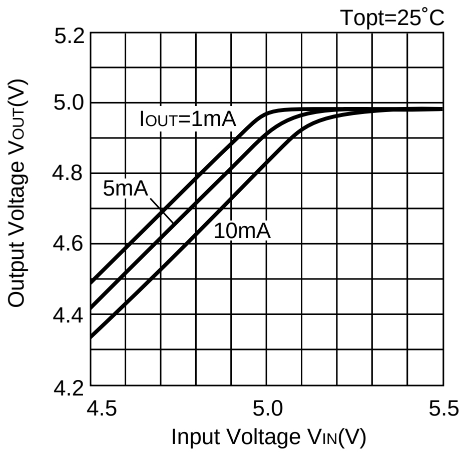
2) Output Voltage vs. Input Voltage

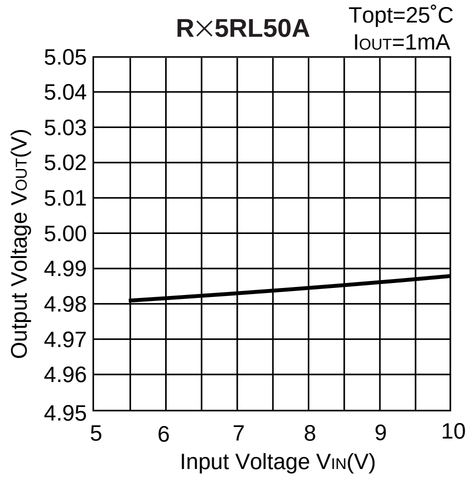




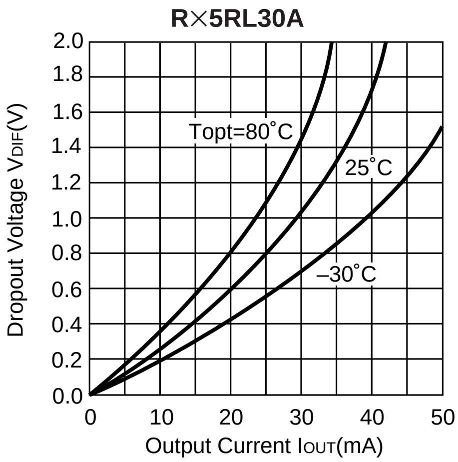


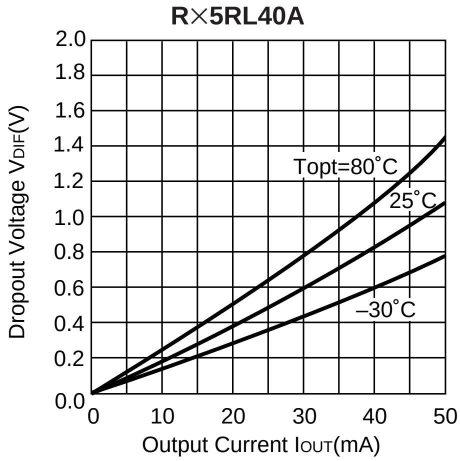


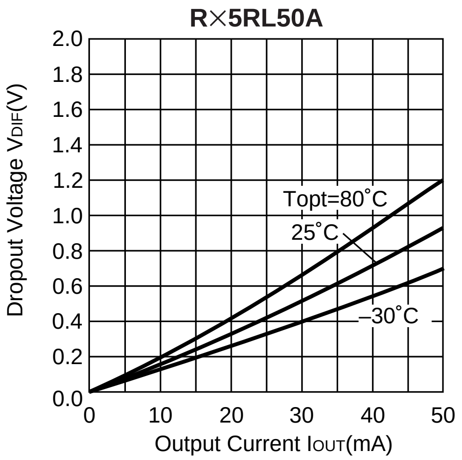




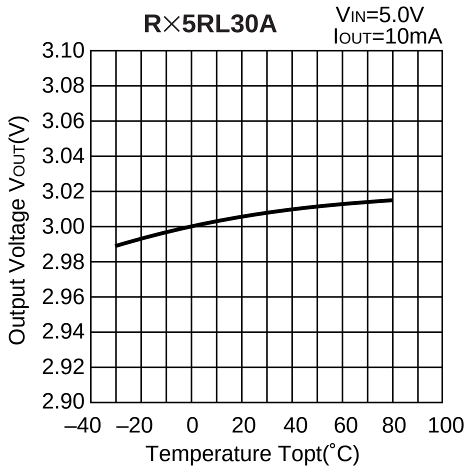
3) Dropout Voltage vs. Output Curret

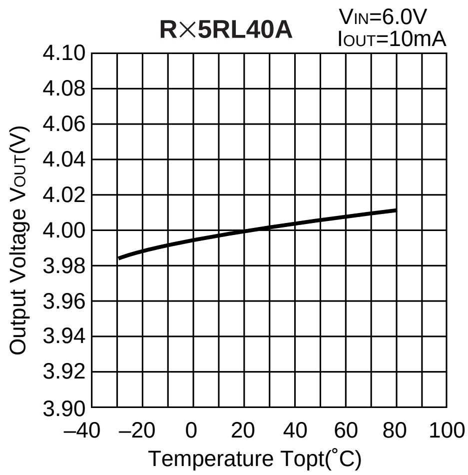


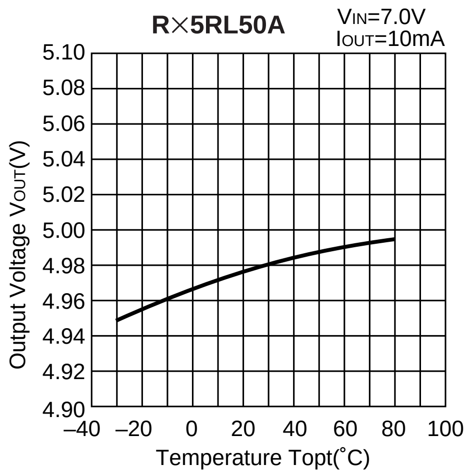




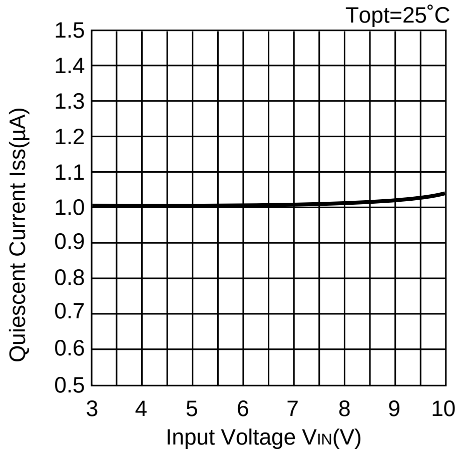
4) Output Voltage vs.Temperature

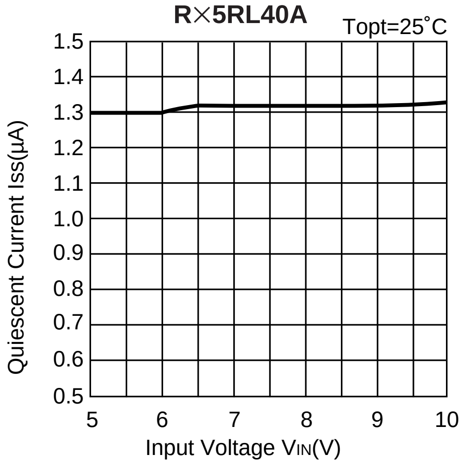


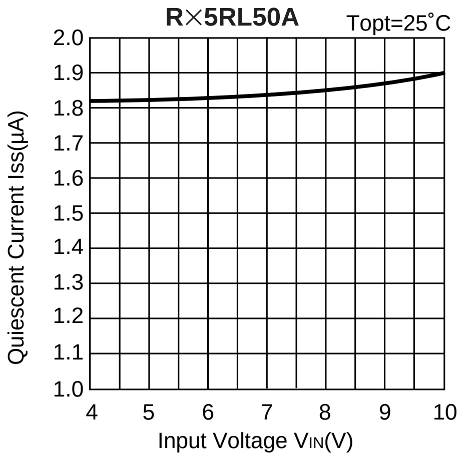




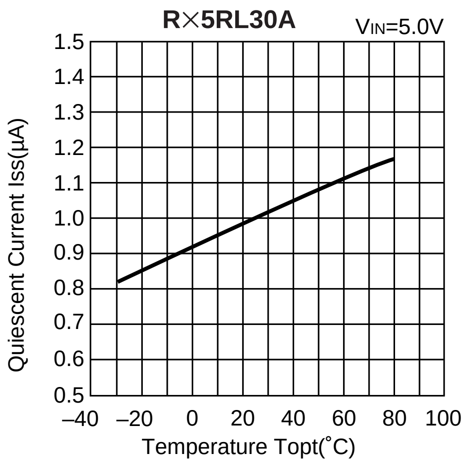
5) Quiescent Current vs. Input Voltage

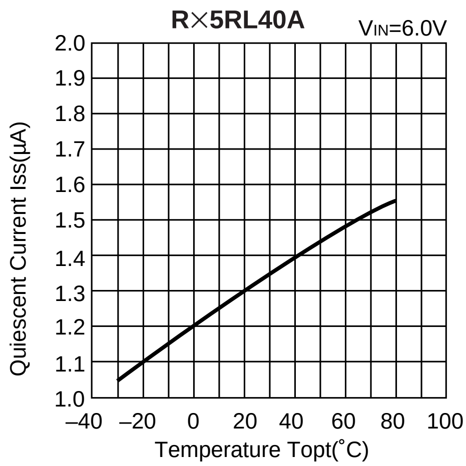






6) Quiescent Current vs. Temperature





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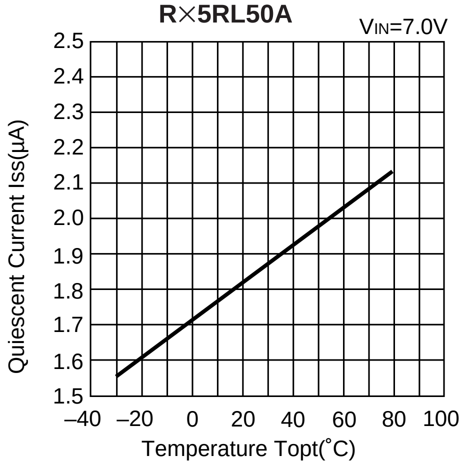
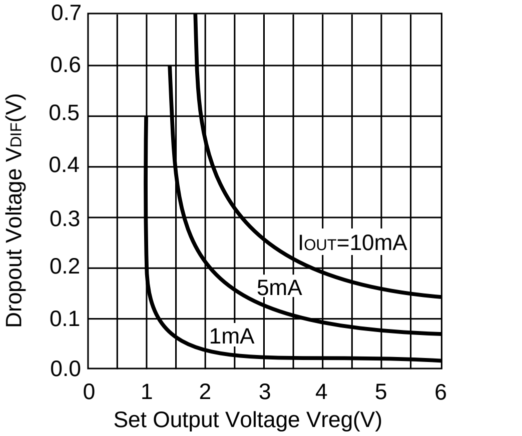
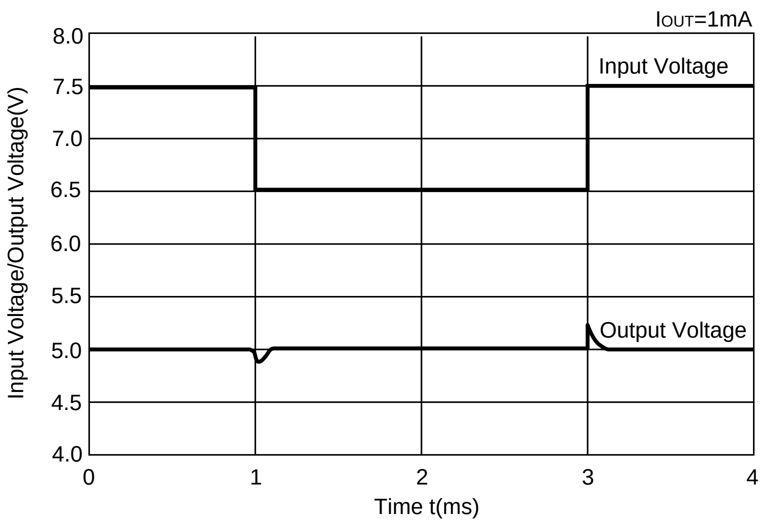


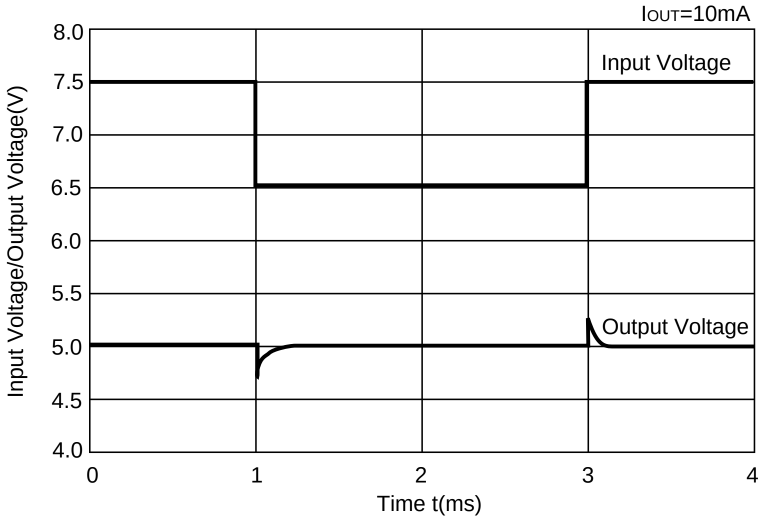
7) Dropout Voltage vs. Set Output Voltage



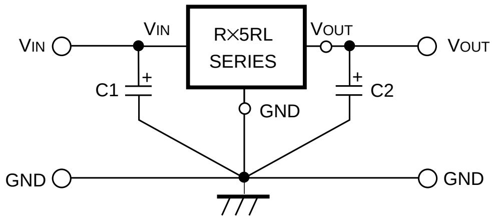
8) Line Transient Response (1)



9) Line Transient Response (2)



TYPICAL APPLICATION

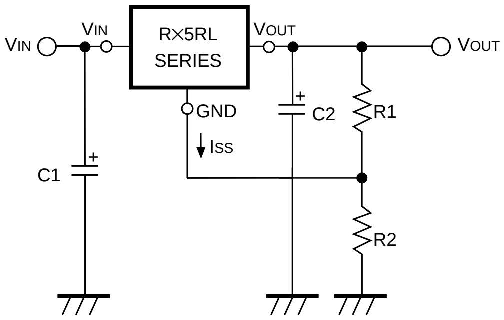


In R×5RL Series, a constant voltage can be obtained without using Capacitors C1 and C2. However, when the wire connected to Vin is long, use Capacitor C1. Output noise can be reduced by using Capacitor C2.

Insert Capacitors C1 and C2 with the capacitance of 0.1µF to 2.0µF between Input/Output Pins and GND Pin with minimum wiring.

APPLICATION CIRCUITS

• VOLTAGE BOOST CIRCUIT



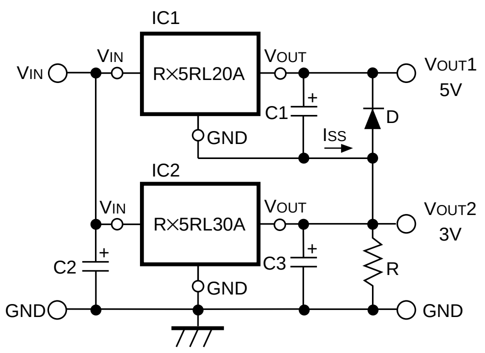
The output voltage can be obtained by the following formula :

$$V_{OUT}=V_{reg}^{*1}\cdot(1+R2/R1)+I_{SS}\,R\cdot 2$$

Since the quiescent current of R×5RE Series is so small that the resistances of R1 and R2 can be set as large as several hundreds kΩ and therefore the supply current of “Voltage Boost Circuit” itself can be reduced.

Furthermore, since R×5RL Series are operated by a constant voltage, the supply current of “Voltage Boost Circuit” is not substantially affected by the input voltage.

• DUAL POWER SUPPLY CIRCUIT



As shown in the circuit diagram, a dual power supply circuit can be constructed by using two R×5RL Series.

This circuit diagram shows a dual power supply circuit with an output of 3V and an output of 5V. When the minimum output current of IC2 is larger than I_{SS} of IC1, Resistor R is unnecessary. Diode D is a protection diode for the case where $V_{OUT}2$ becomes larger than $V_{OUT}1$.

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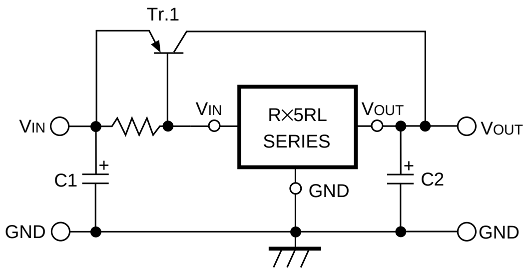
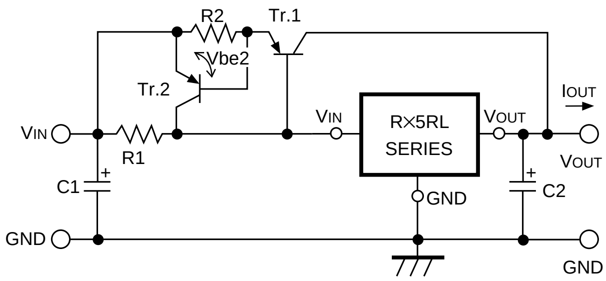
- **CURRENT BOOST CIRCUIT**



Output current of 60mA or more can be obtained by the current boost circuit constructed as shown in this circuit diagram.

- **CURRENT BOOST CIRCUIT WITH OVERCURRENT LIMIT CIRCUIT**



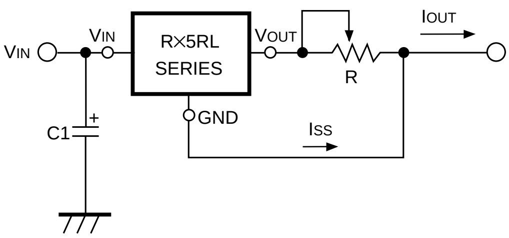
A circuit for protecting Tr.1 from the destruction caused by output short-circuit or overcurrent is shown in this circuit diagram.

When the voltage reduction caused by the current ($\fallingdotseq I_{OUT}$) which flows through R2 reaches Vbe2 of Tr.2 by additionally providing the current boost circuit with Tr.2 and R2, Tr.2 is turned ON and the base current of Tr.1 is increased, so that the output current is limited.

Current limit of Overcurrent Limit Circuit is obtained as follows :

$$I_{OUT} \fallingdotseq Vbe2/R2$$

- **CURRENT SOURCE**



A current source with the structure as shown in this circuit diagram can be used. Output Current I_{OUT} is obtained as follows :

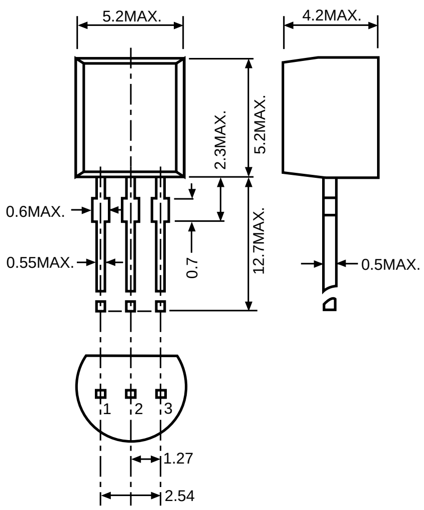
$$I_{OUT} = Vreg^{*1}/R + I_{SS}$$

Take care that Output Current I_{OUT} does not exceed its allowable current.

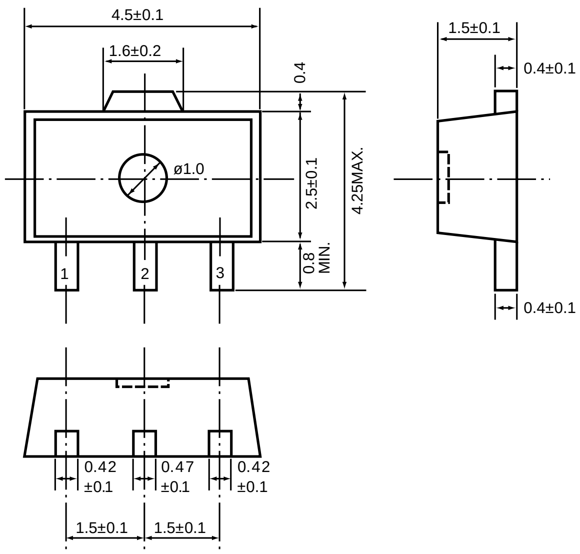
*1) Vreg : Set Output Voltage of R×5RL Series.

PACKAGE DIMENSIONS (Unit: mm)

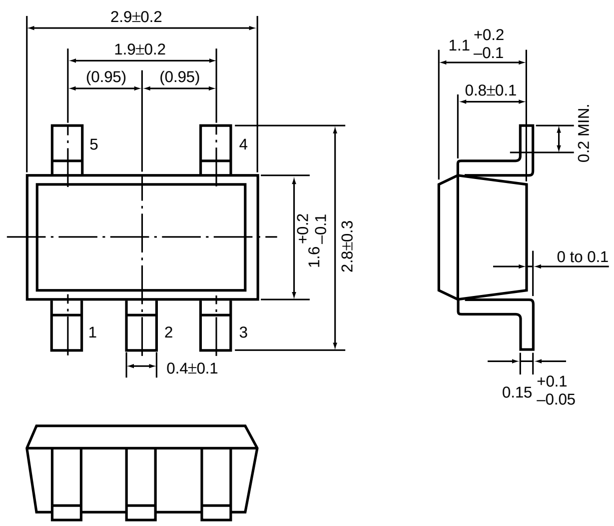
· **TO-92**



· **SOT-89**

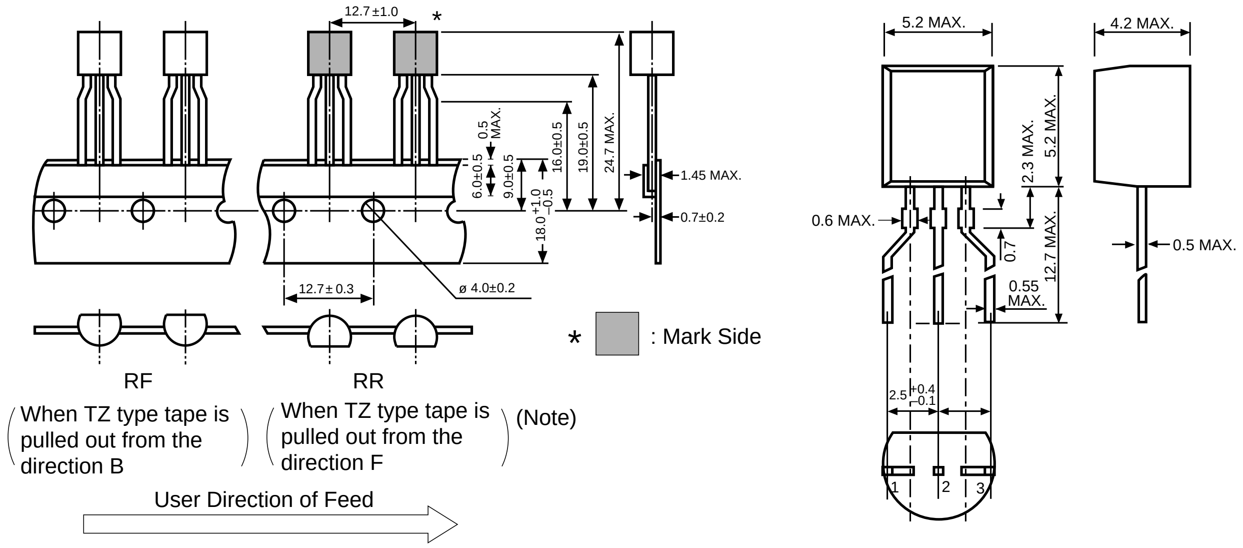


· **SOT-23-5**



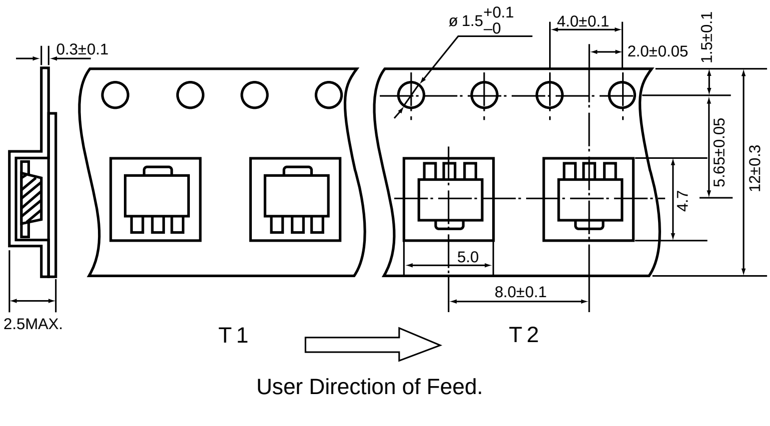
TAPING SPECIFICATIONS (Unit: mm)

· TO-92



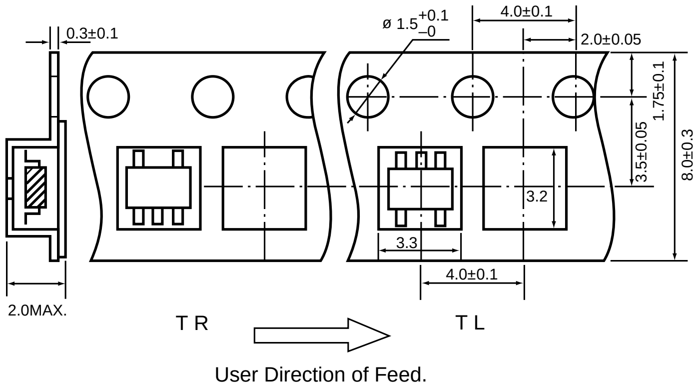
(Note) When taping is performed, the pins of TO-92 are subjected to a particularforming.

· SOT-89



(Note) TZ type tape is not in the form of a reel, but is packed in a zigzag state in a box. Therefore, the tape can be used as either an RF type tape or an RR type tape,depending upon the pulling out direction (B or F).

· SOT-23-5



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